CHAPTER 14

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Egg Dehydration

Removal of water from foods to a low enough level stops growth of microorganisms and slows chemical reaction rates. Thus, dehydration can be used for preservation of food. It is nature's way of keeping certain foods, such as grains, and man learned centuries ago about the value of drying fruits, meats, and other materials.

Dehydration is a successful way of preserving eggs, and the egg-drying industry has developed over several years. Research has played a major role in solving problems which involve stability, functional properties, and quality of dried-egg products. Dried eggs have the following advantages:

(1) They can be stored at low cost under dry storage or refrigeration with reduced space requirement.
(2) Transportation cost is low because water has been removed.
(3) They are easy and clean to use.
(4) They can be used in, and are necessary for, the many new convenience foods.

Early records of egg dehydration in this country date back to about 1880, when Charles LaMont was issued a U.S. patent. At about the same time, W. O. Stoddard started to dry eggs in St. Louis, Missouri, and commercial production of dried egg had its beginning. In the early 1900's, China had a large supply of eggs at a very low cost. Germans, Americans, and others developed processes to produce dried-egg products, and they set up plants in China. The pan-drying of egg white was developed using an egg white that had been naturally fermented. The stability of this product was excellent, and it was not known until many years later that this product was stable because the natural glucose had been removed in the fermentation. Whole egg and yolk products were dried in China by a belt-drying method, as well as by pan-drying.

Prior to 1930, the low cost of egg products out of China gave little incentive to dry eggs elsewhere. Tariffs on eggs coming into this country from China were increased during the 1920's. Drying of whole egg and yolk products in the U.S. began about 1930, and has expanded since that time. A great surge came during World War II, when there was a tremendous need for dried eggs by the military and also by the Lend-Lease Program. In 1944, there were 135 spray dryers producing dried whole egg. Total production in that year was over 300 million pounds.

Pan-drying of white also began in the U.S. in the early 1930's. Although it was thought at first that this was the only way to dry whites, spray-drying was

Exhibit 6

egg yolk in the liquid whites. If egg white is absolutely free of egg yolk, it can be dried under mild conditions, such as in freeze drying or low-temperature pan-drying with practically no loss of whipping properties. As minute quantities of yolk are added to the egg white, it loses its whipping properties when dried, even under mild conditions. Heating egg white contaminated with yolk at 54°C for 15 min and 38°C for 24 hr helps whipping properties of the liquid, but the benefits are not apparent after spray-drying.

Pancreatic lipase improves egg white with yolk. One-tenth as much yolk is required to reduce foaming properties of spray-dried egg whites as is needed to affect liquid egg white.

In spray-drying, eggs are subjected to certain physical forces which can affect their properties. Pumping and atomization are examples of treatments which can be relatively severe. Pumping subjects a liquid to shear forces, while atomization subjects it to both shear forces and to new surface formation.

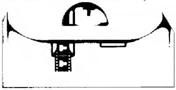
How shear forces affect egg white can be demonstrated by homogenization. Homogenization with conventional equipment can have an adverse effect on the whipping properties of egg white. The degree of change is related to homogenization pressure. The damage is actually attributed to the shear forces, which mechanically disrupt the physical structure of the proteins. On the other hand, pressure per se under 5,000 psi causes no change in the viscosity and functional property of egg white. Pressure by itself above 5,000 psi can cause coagulation of egg white.

Surface formation during atomization will result in surface denaturation and may cause some change in the functional properties of egg white. Large new surfaces are formed, and egg white protein spreads as a monomolecular layer over these surfaces and becomes irreversibly denatured. The amount of area depends on particle size. This is illustrated in Fig. 14.2. Although the area is great, the actual percentage of protein that is denatured under normal atomization for spray-drying is relatively small. No adverse effects on whipping properties are noted until the amount of new surface formed is above 4,000 sq cm per cubic centimeter. This is equivalent to a mean particle diameter of 15 microns.

Many different conditions and ingredients have an affect on egg white when spray-dried. Chemical additives such as acids and whipping aids, are discussed later. Studies on the spray-drying of egg whites over a pH range of 4.0 to 10.0 found the highest angel cake performance at a pH 8.5. At this pH, there was also an indication of less protein damage and greater heat coagulability.

Heat can also have an adverse effect on the whipping properties of egg white. Conditions during drying capable of denaturing the egg protein by heat are: pre-heating the liquid; friction from physical handling or shear forces; heat transferred to the product during drying.

During spray-drying, the temperature of the atomized particles approaches the wet-bulb temperature of the drying air. This temperature would be less than



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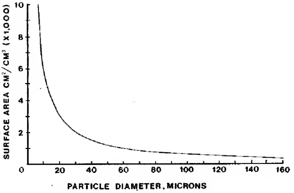

FIGURE 14.2. SURFACE AREA AS DETERMINED BY PARTICLE DIAMETER

49°C even when atmospheric conditions are relatively humid. Thus, under most conditions, temperature would not be expected to go high enough to cause damage to egg white. When the product becomes dry, the temperature rises. However, at this point, the dried egg white is quite stable. Pre-heating of the liquid or heat from friction due to pumping and atomization would be more likely causes for heat denaturation during spray-drying. On the other hand, during pan-drying, where rate of evaporation is slow by comparison, it is possible for too rapid heat transfer at too high temperature to result in heat denaturation.

Heating egg white above 57°C can cause loss of whipping properties. Loss of whip has been observed when heating egg white to only 49°C for 1 hr or even at 43°C for 6 hr. Egg white pasteurized at 57°C for 4 min produces poor angel cakes. Increased whip time and reduced angel cake volume results when heating egg white at 54°C for 3 min, but a recovery of volume occurs when the liquid was spray-dried. However, egg white can be pasteurized at its natural pH (9.0) below 57°C and spray-dried with little effect on whipping properties and on functional properties, as measured by angel cake tests.

A beating time increase, but no effect on angel cake volume results from heating egg white liquid 2 min at 53°C, 56°C, and 57°C. Triethyl citrate and triacetin, but not sodium lauryl sulfate, restore beating time. Egg white is stabilized when pH is reduced to neutral and a metal salt, such as aluminum sulfate, is added. The proteins except for conalbumin, are more stable at this pH and the metal ion complexes with conalbumin to make it more heat-stable. (This is discussed in Chapter 12). Damage to the whipping properties of egg white during pasteurization is caused by heat denaturation of the ovomucinlysozyme complex. Ovomucin helps stabilize egg white foam, and increase in beating time

of egg white when pasteurized is apparently due to loss of foam stability because of damage to ovomucin.

As noted before, egg white is very stable in the dry state, particularly with the natural glucose removed. This stability can be demonstrated at moisture levels below 20%. Thus, whipping properties are not affected unless excessively high temperatures are reached. Dried egg whites were heated to 82°C for 2 hr and no adverse effect on whipping and angel cake making properties were found.

The effect of drying on the whipping properties of yolk-containing products will now be considered. Yolk is a complex balance of proteins, lipids, and other constituents. Loss in whipping properties during drying is apparently due to the breakdown of finely emulsified fat globules into coalesced free fat. When the drying of whole egg or yolk is observed under the microscope, one can actually see the finely emulsified fat globules breaking down and coalescing as water evaporates from the liquid. Even mild conditions of drying, such as in freeze drying, have been found to cause changes in functional properties of whole egg and yolk. Carbohydrates are added to whole egg and yolk to prevent this loss in foaming properties, as will be covered in a later section. Foaming ability of plain whole egg solids can be improved by increasing the temperature at which the reconstituted material is whipped.

Whole egg and yolk liquids are much more resistant to damage by physical treatment than egg white. Physical forces normally encountered in processing and drying have little effect on functional properties. For example, homogenization at pressures as high as 3,000 psig will cause little or no change in whipping ability of whole egg.

As with egg white, excessive temperatures developed during drying can have an adverse effect on whipping properties and other properties of whole egg and yolk products. Denaturation of liquid whole egg is a function of time and temperature and has been observed to occur in the temperature range of 56 to 66°C by measuring change in viscosity. Just above this range fractional precipitation of protein takes place, and above 73°C coagulation is almost instantaneous. Yolk denatures in the range 63 to 70°C. No change occurs in foaming properties of whole egg liquid pasteurized under standard conditions, but a change has been noted if whole egg is frozen. Homogenization after pasteurization before freezing restores foaming ability.

Dried whole egg and yolk products are more susceptible to heat damage than dried egg white. The amount of heat the dried-egg product absorbs during final stages of drying is important, and depends on the method of drying, as well as on the dryer design and conditions of operation. Also, the conditions under which the dried product is stored will determine how well the product will perform.

Emulsifying.—Egg yolk, whole egg and egg white are all good emulsifiers for food products. Egg yolk is rated as 4 times as effective as egg white as an emulsifier, and whole egg is intermediate. The very excellent emulsifying